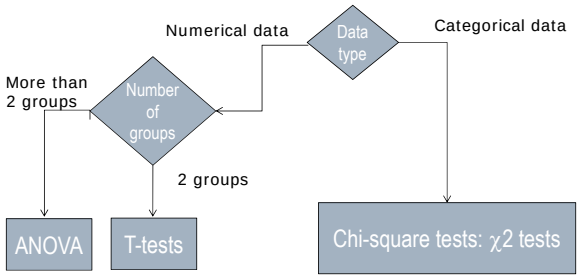
Comparing populations
Bivariate analyses

Which tests to use to compare populations (i.e. comparing groups)



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Numerical data

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Designs

- Independent groups: eg, two or more classes doing a test, experimental and control group, etc
- Repeated measures: eg One sample is measured two or more times (before and after)
- Paired or matched samples: eg, Individuals are matched as pairs on one or more variables and allocated at random, one of each pair to a sample.

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Parametric vs Non-parametric tests

- Parametric tests Assumptions (Conditions for use)
  - Interval or Ratio data levels
  - Normal distribution
  - Equality of variance
  - Samples drawn randomly
- Non-parametric tests
  - No assumptions about distributions or data levels

Testing whether a sample mean differs from the expected…

- T-Test: a univariate hypothesis test using the t-distribution and used when the population standard deviation is unknown and the sample size is small.
- To test whether the mean of a particular sample differs from a mean of the population only by chance.

Independent samples T-Tests Comparing two samples

Example from a horticultural study:

Is there a difference in average plant growth between the low light group of plant and the strong light group of plants in April – (this sample is too small)

	Lighting	N	Mean	Std. Deviation	Std. Error of Mean
Apr	Low light	6	14.9833	3.56590	1.45577
	Strong light	6	18.2000	2.61668	1.06825

H_0: There is no difference in the average growth between plants growing in low light and plats growing in strong light

H_1: There is a statistically significant difference in the average growth between plants growing in low light and plats growing in strong light

Assessing Equality (Homogeneity) of Variance

- Graphs
- Levene's Tests
  - Tests if variances in different groups are the same.
  - Significant = Variances not equal
  - Non-Significant = Variances are equal
- Variance Ratio
  - With 2 or more groups
  - VR = Largest variance/Smallest variance
  - If VR < 2, homogeneity can be assumed.

Independent Samples T Test

		Levene's Test for Equality of Variances	
		F	p-value
Apr	Equal variances assumed	.018	.895
	Equal variances not assumed		

		t-test for Equality of Means				
		t	df	p-value (2-tailed)	Mean Difference	Std. Error Difference
Apr	Equal variances assumed	-1.781	10	.105	-3.2167	1.8057
	~~Equal variances not assumed~~	~~-1.781~~	~~9.174~~	~~.108~~	~~-3.2167~~	~~1.8057~~

Apr: Accept H0, since p-value > 0.05: No difference in plant growth between lighting situations groups

Now do this for July

Open "*LettuceData Subset.sav*"

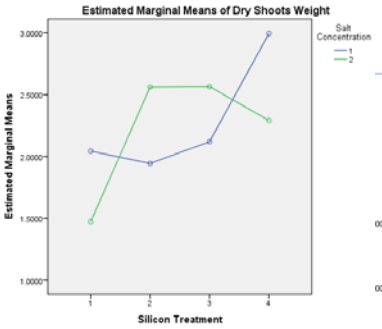
Oneway Analysis of Variance
compare means of three or more populations

H_0: There is no difference in the dry shoot weight between the various levels of silicon treatment

H_1: There is a statistically significant difference in the dry shoot weight between the various levels of silicon treatment

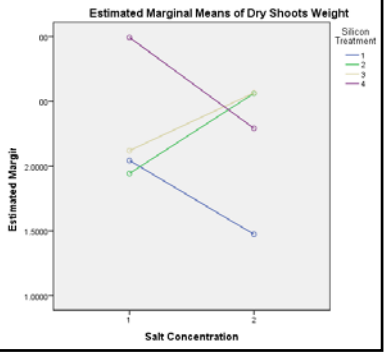
ANOVA					
Dry Shoots Weight					
	Sum of Squares	df	Mean Square	F	p-value.
Between Groups	4.042	3	1.347	3.252	.033
Within Groups	14.913	36	.414		
Total	18.954	39			

Reject H0, since p-value > 0.05: There is a statistically significant difference in the dry shoot weight between the various levels of silicon treatment



Interactions

Since two treatments were applied to the plants – we wonder if there is a possible "interaction" between the two treatments.



Go to Lettuce data

Repeated measures: Paired T-tests

- Measurements taken from athletes before and after a training program:
- H_0: $\mu_{before} = \mu_{after}$

  H_1: $\mu_{before} \neq \mu_{after}$
- Choose $\alpha = 0.05$ for each test

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 3	Post Kenoptrekke	2.32	38	2.839	.461
	Pre Kenoptrekke	1.82	38	2.448	.397
Pair 4	Post Staande verspring	135.37	38	17.190	2.789
	Pre Staande verspring	128.95	38	17.581	2.852
Pair 5	Post 50 m	8.94	38	.879	.143
	Pre 50 m	9.31	38	.962	.156
Pair 6	Post 1600 m	9.17	38	1.474	.2391
	Pre 1600 m	9.30	38	1.505	.2441
Pair 7	Post Opstote	22.95	38	7.877	1.278
	Pre Opstote	20.71	38	7.432	1.206
Pair 8	Post Maagkrulle	26.95	38	9.806	1.591
	Pre Maagkrulle	24.42	38	9.543	1.548
Pair 9	Post Lenigheid	13.16	38	4.359	.707
	Pre Lenigheid	12.00	38	4.713	.765
Pair 10	Post Handmuur gooi	14.03	38	8.326	1.351
	Pre Handmuur gooi	12.87	38	7.960	1.291
Pair 11	Post Touspring	53.18	38	28.856	4.681
	Pre Touspring	48.42	38	28.010	4.544
Pair 12	Post Motoriese vaardigheid	2.42	38	2.332	.378
	Pre Motoriese vaardigheid	1.47	38	1.656	.269
Pair 13	Totaal2	28.37	38	3.242	.526
	Totaal1	23.92	38	4.420	.717

Go to Kids Sport Intervention.sav

Categorical data

Crosstabulations

Note: The data levels for crosstabulations are either

- categorical (nominal or ordinal)

  or

- Numerical (interval or ratio), but classified into groups

Example

	I looked forward to attend Maths classes.			
	Mostly	Sometimes	Mostly Not	Total
Pre (Mathematics)	182	124	70	376
	I looked forward to attend Maths classes.			
	Mostly	Sometimes	Mostly Not	Total
Post (Maths Literacy)	201	118	29	348

Crosstabulation Tables

		I looked forward to attend Maths classes			
		Mostly	Sometimes	Mostly Not	Total
Time	Pre (Mathematics)	182	124	70	376
	Post (Math Literacy)	201	118	29	348
Total		383	242	99	724

Analysis of a crosstabulation table

Number of "Mostly Not" decreased; but so did the total number of learners….

So, is this decrease significant; i.e.

Is there a significant difference in learners attitudes after Maths Literacy lessons?

Use a Chi-square (χ^2) test to analyse this:

Chi-Square Tests

H_0: There is no difference in the perception of mathematics before and after introduction of maths literacy classes

H_1: There is a statistically significant difference in the perception of mathematics before and after introduction of maths literacy classes

Chi-Square Tests

p-value < 0.05

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	17.014(a)	2	0.001
N of Valid Cases	724		

a. 0 cells (.0%) have ***expected counts*** less than 5. The minimum expected count is 22.59.

Significance

- For test result to be significant, the p-value ("Asymp. Sig. (2-sided)" in SPSS) must be < 0.05
- Analysis results from sample which are found to be significant can be generalised to the whole population if
  - the sampling technique was a probability technique AND
  - the sample size in big enough (usually > 30) AND
  - the p-value < 0.05

Results

Reject H0, since p-value < 0.05:

There is a statistically significant difference in the perception of mathematics before and after introduction of maths literacy classes

Expected Counts

80% of expected values must be greater than 5

	Mostly	Sometimes	Mostly not	
Pre	182	124	70	376
	198.9061	125.6796	51.414	376
Post	201	118	29	348
	184.0939	116.3204	47.586	348
	383	242	99	724

		I looked forward to attend Maths classes.					
		Always	Usually	Some-times	Hardly ever	Never	Total
Time	Pre (Mathematics)	137	45	124	35	35	376
	Post (Math Literacy)	147	54	118	17	12	348
Total		284	99	242	52	47	724

	Mostly	Some-times	Mostly not	Total
Pre	182	124	70	376
Post	201	118	29	348
Total	383	242	99	724

Thank you

References

- Burns, R. B. & Burns, R. A. 2008. *Business research methods and statistics using SPSS*, London: SAGE Publications Ltd.
- Levine D, Krehbiel T. C., and Berenson M. L., 2003. *Business Statistics: A First Course,* New York: Prentice Hall
- Remenyi, D., Onofrei, G., English, J. 2009. *An introduction to Statistics using Microsoft Excel.* Reading: Academic Publishing Ltd.

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